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(54) Method and apparatus for installing a ventricular assist device cannulae.

(57) A ventricular assist device cannula of a novel type including a blood drainage cannula tube (12) having a first end and a second end and a blood inlet cannula tube (11) having a first end and a second end with the tubes being attached together to form a sealed section having a convex outer surface (14). An opening is made in a heart, the blood drainage cannula tube (12) is inserted through the opening whereby the first end is disposed in a heart chamber and at the same time the blood inlet cannula tube (11) is inserted through the opening and also through the aortic valve so that the first end thereof is disposed in the aorta. At the convex surface (14), the ventricular assist device cannula is sutured to the heart to hold it in place and to prevent blood drainage therearound. The blood drainage cannula tube is attached to the inlet port of the pump and the second end of the blood inlet cannula tube is connected to the outlet end of the pump whereby this design and method of cannula requires only one opening into the heart instead of two.

## METHOD AND APPARATUS FOR INSTALLING A VENTRICULAR ASSIST DEVICE CANNULAE

This invention relates to a ventricular assist device and, more particularly, to a ventricular assist cannula. The invention concerns a method of using it with left, right or bi-ventricular failure.

Ventricular assist devices (VAD) are gaining increased popularity for use in patients with left, right or bi-ventricular failure. Standard techniques require insertion of a cannula for drainage of the atrium or ventricle with insertion of a second cannula for reinfusion of blood into the aorta or pulmonary artery. This requires two cannulae for a single ventricular assist device and four cannulae for a bi-ventricular assist device. Physicians who have worked with ventricular assist device systems understand the space constraints and the potential kinking or twisting of these cannulae in the chest or at the skin insertion site. In addition, the theory is that the greater number of cannulae that are exteriorized, the greater the chance of transcutaneous contamination and infection.

It is an object of this invention to provide an improved ventricular assist cannula.

According to one aspect of this invention there is provided a ventricular assist cannula comprising: a blood drainage cannula tube having a first end and a second end; a blood inlet cannula tube having a first end and a second end; means for sealingly attaching an intermediate portion of the blood drainage cannula tube to an intermediate portion of the blood inlet cannula tube to form a convex outer surface; annular flexible suturing sleeve means extending around said convex outer surface for attachment to the interior periphery of an opening in a heart; and suture means for sealingly attaching said annular flexible suturing sleeve means to said convex outer surface.

Preferably, the annular flexible suturing sleeve means is dimensioned and configured for attachment to the periphery of a single opening in a heart.

According to another aspect of the invention, there is provided a method of installing a ventricular assist device cannula of a type including a blood drainage cannula tube having a first end and a second end and a blood inlet cannula tube having a first end and a second end, said method comprising:

making an opening in a heart; inserting the blood drainage cannula tube through said opening whereby said first end thereof is disposed in a heart chamber; inserting the blood inlet cannula tube through said opening and through the aortic valve so that said

first end thereof is disposed in said aorta; suturing said blood drainage cannula tube and said blood inlet cannula tube to said opening for sealing said opening and holding said cannula tubes in place;

attaching said second end of said blood drainage cannula tube to the inlet port of a pump; and attaching said second end of said blood inlet cannula tube to the outlet port of said pump. Thus with this design of cannula only one opening into the heart is needed instead of two.

According to another aspect of the invention there is provided a method of installing a ventricular assist device cannulae of a type including a blood drainage cannula tube having a first end and a second end and a blood inlet cannula tube having a first end and a second end, said method comprising:

making an opening in a heart;

inserting the blood drainage cannula tube through said opening whereby said first end thereof is disposed in a heart chamber;

inserting the blood inlet cannula tube through said opening and through the pulmonic valve so that said first end thereof is disposed in said pulmonary artery;

suturing said blood drainage cannula tube and said blood inlet cannula tube to said opening for sealing said opening and holding said cannula tubes in place;

attaching said second end of said blood drainage cannula tube to the inlet port of a pump; and attaching said second end of said blood inlet cannula tube to the outlet port of said pump. Thus, with this design of cannula only one opening into the heart is needed instead of two.

Thus a device and method may be provided which requires making only one hole for each ventricular failure, instead of two as in conventional methods.

One embodiment of the present invention comprises a cannula which contains two lumens fabricated for use in ventricular assist device cannulation. A small lumen cannula may be mounted on a larger lumen cannula. The small diameter lumen cannula may extend beyond the larger cannula preferably by approximately 30 centimeters. This small diameter lumen cannula can be shortened to a desired length. The larger diameter lumen may provide drainage into the ventricular assist device and the small lumen may provide reflow from the ventricular assist device. The cannula may be placed through a purse-string suture in the left or right ventricle.

The larger diameter lumen (drainage lumen)

may be disposed in the ventricle while the smaller lumen cannula may pass through the aorta or pulmonic valve into the aorta or pulmonary artery. thus, for left ventricular assist device use, the double lumen cannula may be positioned as follows. the larger cannula is disposed within the left ventricle while the smaller cannulae passes through the left ventricle across the aortic valve into the aorta.

For right ventricular assist device insertion, the larger cannula may be disposed in the right ventricle and the smaller cannulae may pass through the right ventricle lumen across the pulmonic valve into the pulmonary artery. Exteriorization of these cannulas is basically in straight below the costal margins.

An advantage of the present invention is that it provides an improved method and apparatus for installing ventricular assist device cannulae.

Another advantage of the present invention is that it eliminates the need for making two holes in the heart to install a ventricular assist device cannula in either the right or left ventricle of a heart.

A further advantage of the present invention is that it provides an apparatus having blood inlet and blood drainage cannulae tubes for use with the above mentioned method which can easily be sealed to the inner periphery of an opening in a heart with a standard purse string suture.

Reference is now made to the accompanying drawings, in which:-

Figure 1 is a cross-sectional view through a human heart and showing the placement of a ventricular assist device cannula in the left ventricle and another in the right ventricle thereof; Figure 2 is a cross-sectional view taken along line 2-2 of Figure 1 to show how the two cannula tubes are joined together and sealed so that an easy purse string suture can be made therearound for an effective seal; and Figure 3 is a cross-sectional view of the heart as shown in Figure 1 but showing an alternate arrangement for installation of the apparatus of the present invention in the left and right sides of the heart.

Referring now to the drawings wherein like reference numerals designate identical or corresponding parts throughout the several views, Figure 1 shows a human heart having the apparatus of the present invention attached thereto. A ventricular assist device (10), shown in the present invention, has a small lumen inlet tube (11) attached to a larger blood drainage cannula tube (12) at the juncture shown in Figure 2.

These tubes (11) and (12) are made of standard flexible plastic material and in one embodiment thereof, as shown in Figure 2, a flexible plastic material is used to bond the two tubes (11) and (12) together and to fill in the openings around

the joint between the two so as to form a convex surface (14). It is important that this convex surface (14) be present because if a concave surface (such as if the substance (13) were not used to fill in between the tubes at the juncture thereof) then it would be difficult to seal around a concave surface at (14) by the use of a standard purse string suture (15).

The small lumen cannula tube (11) extends beyond the larger cannula tube (12) by approximately 30 centimeters. This small lumen cannula (11) can be cut shorter to a desired length by the surgeon using it. the larger drainage lumen cannula (12) provides drainage to the ventricular assist device (10) and the small lumen cannula tube (11) provides reflow from the ventricular assist device (10). The device (10) is placed through an opening formed in the heart at either the left ventricle or right ventricle as shown in Figure 1, or in both as shown in Figure 1.

The larger drainage lumen cannula tube (12) has an open end (16) and additional flow openings (17) positioned in the ventricle while the smaller inlet lumen cannula tube (11) passes through the aortic valve, in the case of the left ventricle, or through the pulmonary artery, the case of the right ventricle usage.

Therefore, for the left ventricular assist device usage, the double lumen cannula (10) is positioned by placing the blood drainage cannula tube (12), as shown in Figure 1, in the left ventricle as shown, while the blood inlet cannula tube (11), is placed through the left ventricle and across the aortic valve so that the open end extends into the aorta.

For right side ventricular assist device insertion, an opening is made in the right ventricle in the position shown in Figure 1 and the blood drainage cannula tube (12) is inserted therethrough to the position shown in Figure 1, while the smaller blood inlet cannula tube (11) passes through the right ventricle lumen across the pulmonic valve and until the open end thereof is in the pulmonary artery. Of course, a purse string suture is then made around the convex portion (14) of the device (10) by a rayon annular collar (15), or the like. The suture is completed by sewing the rayon collar (15) to the heart itself. Exteriorization of these cannulas is basically straight below the costal margins. A left ventricular assist device will require only one cannula device (10) as shown and, likewise, a right ventricular device would require only one cannula as well. A bi-ventricular assist device will, of course, require two of the devices (10) such as shown in Figure 1.

It will be understood of course that the devices (10) do not need to be attached precisely in the position shown in Figure 1. For example, Figure 3 shows an alternate positioning of the devices (10)

in the left and right sides of the heart.

Accordingly, it will be appreciated that the preferred embodiment disclosed herein does indeed accomplish the aforementioned objects. Obviously many modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

### Claims

1. A ventricular assist cannula comprising:  
a blood drainage cannula tube having a first end and a second end;  
a blood inlet cannula tube having a first end and a second end;  
means for sealingly attaching an intermediate portion of the blood drainage cannula tube to an intermediate portion of the blood inlet cannula tube to form a convex outer surface;  
annular flexible suturing sleeve means extending around said convex outer surface for attachment to the interior periphery of an opening in a heart; and suture means for sealingly attaching said annular flexible suturing sleeve means to said convex outer surface.
2. a method of installing a ventricular assist device cannula of a type including a blood drainage cannula tube having a first end and a second end and a blood inlet cannula tube having a first end and a second end, said method comprising:  
making an opening in a heart; inserting the blood drainage cannula tube through said opening whereby said first end thereof is disposed in a heart chamber;  
inserting the blood inlet cannula tube through said opening and through the aortic valve so that said first end thereof is disposed in said aorta;  
suturing said blood drainage cannula tube and said blood inlet cannula tube to said opening for sealing said opening and holding said cannula tubes in place;  
attaching said second end of said blood drainage cannula tube to the inlet port of a pump; and attaching said second end of said blood inlet cannula tube to the outlet port of said pump whereby this design of cannula only one opening into the heart is needed instead of two.
3. A method of installing a ventricular assist device cannulae of a type including a blood drainage cannula tube having a first end and a second end and a blood inlet cannula tube having a first end and a second end, said method comprising:  
making an opening in a heart;  
inserting the blood drainage cannula tube through

5 said opening whereby said first end thereof is disposed in a heart chamber;  
inserting the blood inlet cannula tube through said opening and through the pulmonic valve so that said first end thereof is disposed in said pulmonary artery;  
10 suturing said blood drainage cannula tube and said blood inlet cannula tube to said opening for sealing said opening and holding said cannula tubes in place;  
attaching said second end of said blood drainage cannula tube to the inlet port of a pump; and attaching said second end of said blood inlet cannula tube to the outlet port of said pump whereby  
15 with this design of cannula only one opening into the heart is needed instead of two.

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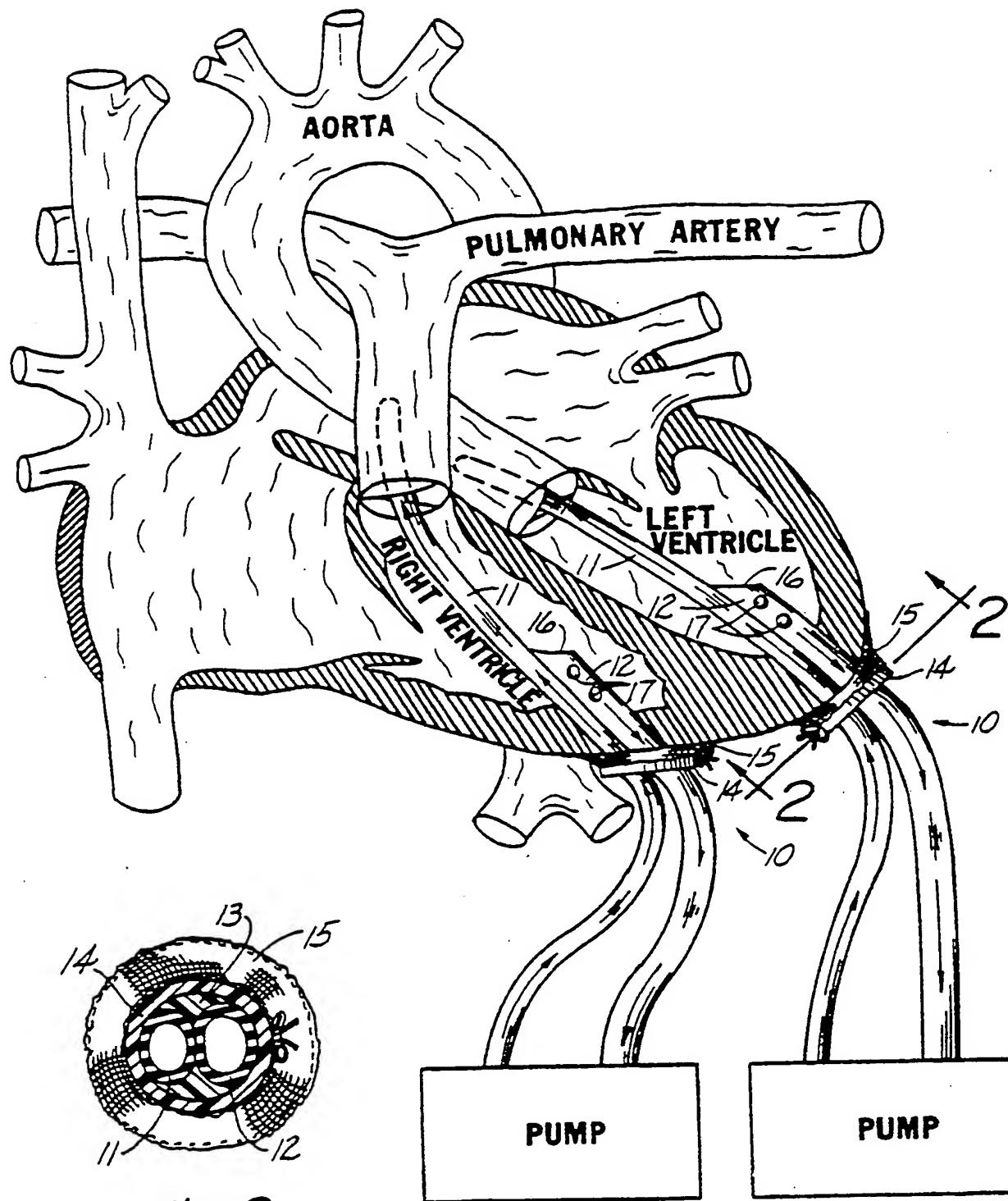


Fig. 2

Fig. 1

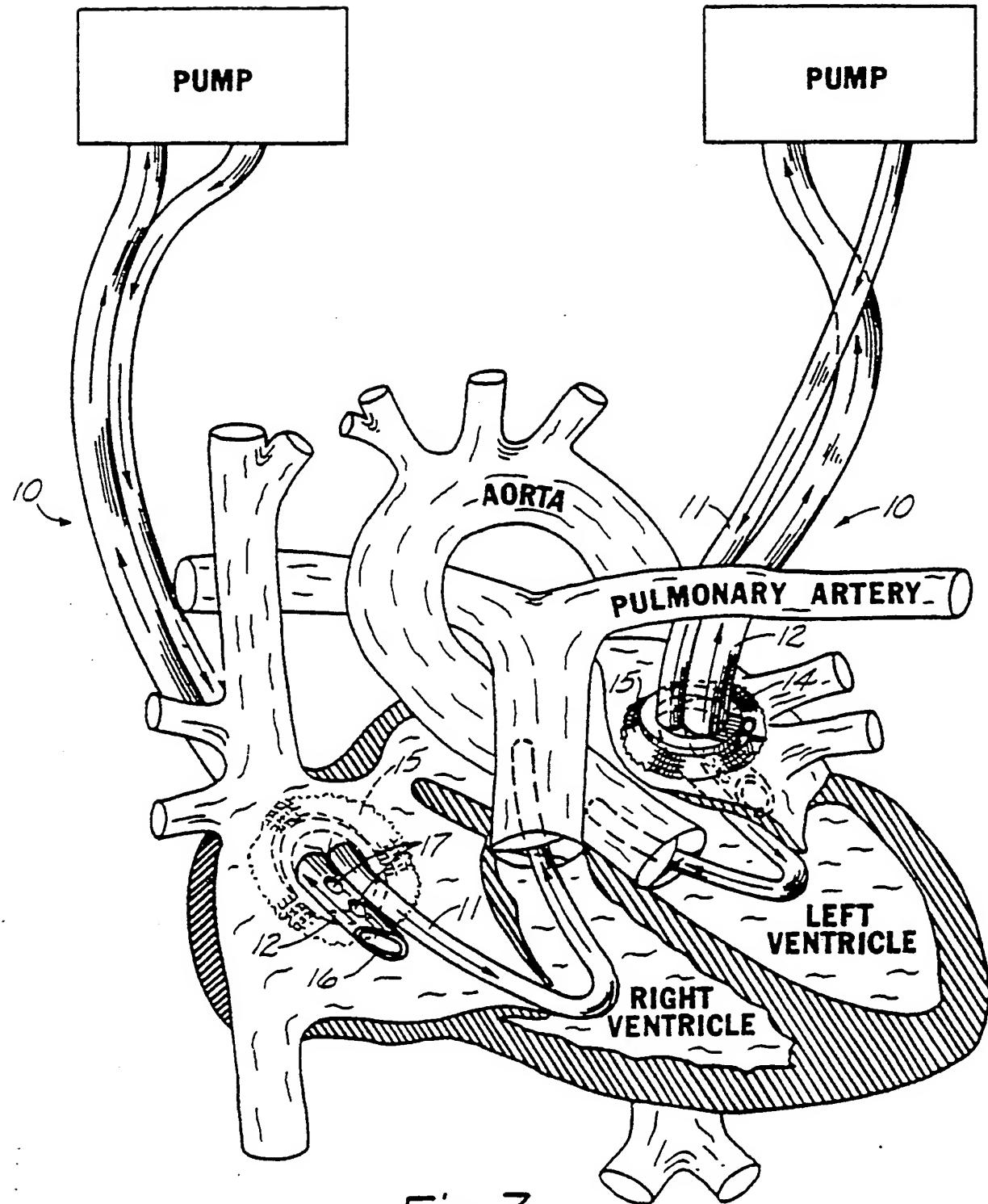


Fig. 3



EP 90305700.8

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int Cl.)
A	<p><u>US - A - 4 309 994</u> (GRUNWALD) * Column 3, lines 14-57; fig. 4,5 *</p> <p>---</p>	1	<p>A 61 M 1/10 A 61 M 25/00</p>
A	<p><u>US - A - 4 248 224</u> (JONES)</p> <p>---</p>		
A	<p><u>US - A - 4 129 129</u> (AMRINE)</p> <p>-----</p>		
			TECHNICAL FIELDS SEARCHED (Int Cl.)
			<p>A 61 M 1/00 A 61 M 25/00</p>
The present search report has been drawn up for all claims			
Place of search VIENNA	Date of completion of the search 18-09-1990	Examiner VELINSKY-HUBER	
CATEGORY OF CITED DOCUMENTS			
<p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p>		<p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons &amp; : member of the same patent family, corresponding document</p>	



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### 54 Catheter and assembly for extracorporeal circulation.

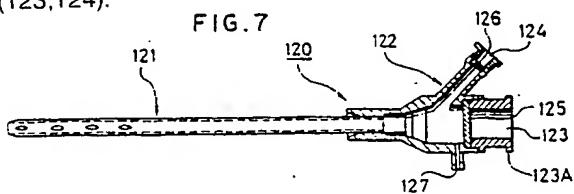
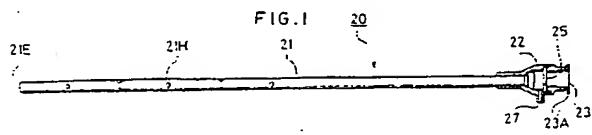
57 The present invention, there is provided a catheter (20) comprising:  
a hollow body (21) introducible into the blood vessel and opened (21E) at a distal end thereof; and  
a proximal end (22) communicating with the hollow inside of the body (21) and having an introduction passage (23) with a hemostatic valve (25) disposed therein,  
the body (21) having side hole (21H) means formed therein.

As has been described above, according to the present invention, there is provided a catheter (20) that has a diameter small enough to facilitate percutaneous insertion at the time of auxiliary blood circulation but is capable of assuring a sufficient amount of drawn-out or pumped-in blood.

The present invention, there is provided an as-

sembly for extracorporeal circulation comprising:  
an introducing instrument (120); and  
a connecting instrument (130),  
the introducing instrument (120) including a sheath (121) introducible into the blood vessel, and a proximal part (122) communicating with the sheath (121) and having a plurality of introduction passages (123,124) with hemostatic valves (125,126) disposed therein,

the connecting instrument (130) including a tubular portion (131) capable of being connected with at least one of the introduction passages (123,124) of the proximal part (122) of the introducing instrument (120) and capable of being inserted in a liquid-tight manner through the hemostatic valve (125,126) disposed in the connected introduction passage (123,124).



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## CATHETER AND ASSEMBLY FOR EXTRACORPOREAL CIRCULATION

## BACKGROUND OF THE INVENTION

## (Field of the Invention)

The present invention relates to a catheter and an assembly for extracorporeal circulation which are suitable for use in heart treatment and the like.

## (Prior Art)

Patients suffering from heart failure, e.g. myocardial infarction, have hitherto been treated by various methods such as percutaneous transluminal coronary angioplasty (hereinafter abbreviated to "PTCA"), and Intra Aortic Balloon Pumping (hereinafter abbreviated to "IABP").

In PTCA, a balloon is inserted into the constricted lesion of the coronary artery, and is then inflated to dilate the constricted lesion.

In IABP, a balloon is inserted in the base portion of the aorta, and is then repeatedly inflated and deflated synchronization with the heart beat to increase blood flow in the coronary artery, hence, to assist a heart whose function has degraded.

## (Problems to be Overcome by the Invention)

The conventional methods involve the following problems :

① PTCA treatment may put a patient into a shocked condition, which is very dangerous; and ② IABP treatment can increase blood flow only to a limited extent because the heart assisting function can be degraded with a drop in the cardiac output, sometimes failing to assure the patient's recovery.

Because of the problems ① and ②, it is sometimes necessary for heart treatment to be performed simultaneously with auxiliary circulation of the blood, wherein an extracorporeal blood circulation circuit is formed for this purpose during the heart treatment.

During the treatment of heart failure, e.g. acute myocardial infarction, because the heart function is degraded, emergency auxiliary circulation of blood is performed to add oxygen and remove carbon dioxide.

In such cases where auxiliary blood circulation is necessary, there is too little time to form the circuit by open heart surgery.

In such cases, therefore, catheters capable of

percutaneous insertion are employed to allow blood to be drawn from and pumped back into the patient's body through the catheters, thereby effecting extracorporeal circulation. For instance, the catheter on the blood-drawing side of the circuit is inserted into the femoral vein by an insertion method, described later, with the distal end of the catheter reaching through the bifurcation of the vena cava to the right atrium and being indwelt therein.

(A) However, with a conventional catheter device, since percutaneous insertion is conducted, the diameter of a catheter is inevitably small, thereby involving a great resistance to the flow of blood, hence, a great pressure loss. Thus, it is difficult to assure sufficient amounts of drawn-out blood and pumped-in blood.

An object of the present invention is to provide a catheter that has a diameter small enough to facilitate percutaneous insertion at the time of auxiliary blood circulation but is capable of assuring sufficient amounts of drawn-out and pumped-in blood.

(B) When extracorporeal circulation is conducted simultaneously with the execution of PTCA or IABP heart treatment, in order to transfer oxygenated blood from a lung apparatus into the blood vessel, a blood-transfusion catheter device must be inserted into a blood vessel portion which is different from the portion where a balloon is inserted for the PTCA or IABP treatment. Thus, the insertion of the blood-transfusion catheter device makes the entire operation complicated, and creates an additional burden on the patient.

Another object of the present invention is to provide an assembly for extracorporeal circulation that enables extracorporeal circulation to be effected simultaneously with the execution of heart treatment.

## DISCLOSURE OF THE INVENTION

(A) To these end, according to a first aspect of the present invention, there is provided a catheter comprising:

a hollow body introducible into the blood vessel and opened at a distal end thereof; and a proximal end communicating with the hollow inside of the body and having an introduction passage with a hemostatic valve disposed therein, the body having side hole means formed therein.

According to a second aspect of the present invention, there is provided catheter, wherein the body has a plurality of side holes.

According to a third aspect of the present invention, there is provided a catheter, wherein when the area of the opening at the distal end of the body is expressed as  $S_1$  and the total opening area of the side hole means is expressed as  $S_2$ , the relation of  $2 \times S_1 \geq S_2 \geq 0.5 \times S_1$  is satisfied.

According to a fourth aspect of the present invention, there is provided a catheter, wherein when the distance from the distal end of the body to the side hole closest to the proximal end is expressed as  $L_1$  and the whole length of the body is expressed as  $L_2$ , the relation of  $2/3 \times L_2 \geq L_1 \geq 1/3 \times L_2$  is satisfied.

A catheter according to the present invention is used with its body being percutaneously inserted into the blood vessel.

When an auxiliary blood circulation operation is to be performed during PTCA or IABP heart treatment or during the treatment of acute heart failure, e.g. myocardial infarction, a blood circulation instrument is inserted into the introduction passage of the catheter. The hemostatic valve in the passage allows the blood circulation instrument to be inserted in a liquid tight manner and without involving any blood leakage.

When the catheter is on the blood-drawing side, the associated blood circulation instrument is connected with a blood-drawing line of the extracorporeal circulation circuit so that blood in the patient's body is drawn out to the circuit through the catheter body and the blood circulation instrument.

When the catheter is on the blood pumping-in side, the associated blood circulation instrument is connected with a blood pumping-in line of the circuit so that the extracorporeally circulated blood is pumped into the blood vessel through the blood circulation instrument and the catheter body.

With the catheter according to the present invention which has at least one side holes formed in the catheter body, blood is drawn out or pumped in through not only the opening at the distal end of the body but also the side hole(s) of the body. Therefore, the catheter according to the present invention is able to operate with a small resistance to the flow of blood from the blood vessel to the catheter body or vice versa, hence, with a reduced pressure loss. Thus, the catheter according to the present invention which has a diameter small enough to facilitate percutaneous insertion is capable of reducing the pressure loss, thereby assuring sufficient amounts of drawn-out or pumped-in blood.

The catheter according to the present invention which has the side hole(s) in the body is also such that, when it is used on the side of the blood-drawing line, the negative pressure applied through the line on the catheter body is distributed among the opening at the distal end and the side hole(s).

Therefore, it is possible to reduce the risk that the catheter body subjected to the negative pressure may suck the blood vessel wall, to have the openings through which blood flows in, i.e., the opening at the distal end and the side holes, closed.

If the catheter according to the present invention has side holes whose total opening area and position satisfy the above-specified relationship, the amount of the blood drawn out or pumped in through the opening at the distal end of the catheter body can be at least a certain proportion to the total amount of drawn-out blood. Therefore, a certain amount of blood can be positively drawn out or pumped in at the target portion within the blood vessel where the distal end of the catheter body is indwelt, relative to the amount of blood drawn out or pumped in through the side hole(s).

(B) To these end, according to a fifth aspect of the present invention, there is provided an assembly for extracorporeal circulation comprising:  
20 an introducing instrument; and  
a connecting instrument,  
the introducing instrument including a sheath introducible into the blood vessel, and proximal part 25 communicating with the sheath and having a plurality of introduction passages with hemostatic valves disposed therein,  
the connecting instrument including a tubular portion capable of being connected with at least one 30 of the introduction passages of the proximal part of the introducing instrument and capable of being inserted in a liquid-tight manner through the hemostatic valve disposed in the connected introduction passage.

According to a sixth aspect of the present invention, there is provided an assembly, wherein the sheath of the introducing instrument has an inner diameter of 3 to 10 mm.

According to a seventh aspect of the present invention, there is provided an assembly, wherein the sheath of the introducing instrument has side hole means formed therein.

According to a eighth aspect of the present invention, there is provided an assembly, wherein the proximal part of the introducing instrument has a passage capable of communicating with a tube having a cock at one end thereof.

An assembly for extracorporeal circulation according to the present invention is used with the sheath of the introducing instrument being percutaneously inserted into the blood vessel.

At this time, a catheter, for example, a PTCA catheter (i.e., a unit having a guide catheter and a balloon catheter guided thereby) is inserted through one of the introduction passages at the proximal part of the introducing instrument. The hemostatic valve in the introduction passage allows the catheter to be inserted into the passage in

a liquid tight manner and without the risk of blood leakage. The inserted catheter is introduced through the sheath to the target portion within the blood vessel (the constricted lesion of the coronary artery).

Alternatively, an IABP balloon catheter) may be inserted into one of the introduction passages of the introducing instrument. The hemostatic valve in the introduction passage also allows such a catheter to be inserted into the passage in a liquid tight manner and without the risk of blood leakage. The inserted catheter is introduced through the sheath to the target portion of the blood vessel (the aorta).

The introducing instrument may be able to allow a plurality of catheters, such as a PTCA catheter and an IABP catheter, to be individually inserted into the plurality of introduction passages so that these catheters are introduced through the sheath in a parallel manner to the respective target portions of the blood vessel.

During the PTCA or IABP heart treatment operation, when the patient goes into a shocked condition, or when it is necessary to strengthen the heart assisting function of the IABP, the connecting instrument is inserted into another passage of the introducing instrument which is not the passage(s) through which the PTCA and/or IABP catheters are introduced. The hemostatic valve in this other passage enables liquid-tight, blood-leakage free insertion of the connecting instrument. The thus inserted connecting instrument is connected with a blood-transfusion line of an extracorporeal circulation circuit so that, simultaneously with the PTCA or IABP operation, the extracorporeally circulated and oxygenated blood is transferred into the blood vessel through the connecting instrument and the sheath of the introducing instrument.

When the patient is in a critical condition, the connecting instrument may be inserted into one of the introduction passages of the introducing instrument prior to the start of a PTCA or IABP operation so that extracorporeal circulation can be started whenever necessary. In this way, the necessary heart treatment can be performed with a higher level of safety.

In carrying out the present invention, the diameter of a catheter (e.g., a PTCA catheter) inserted into the sheath of the introducing instrument is generally 8F or 9F (F = 1/3 mm). Therefore, in order to assure that, when a catheter is inserted into the sheath and indwelt, the blood from the blood-transfusion line of the extracorporeal circulation circuit is smoothly transferred through the connecting instrument and the sheath portion into the blood vessel, the sheath should preferably have an inner diameter of 3 to 10 mm, more preferably, 5 to 7 mm. If the inner diameter of the sheath is less than 3 mm, it is not possible to assure a sufficient

flow passage area between the outer periphery of the catheter and the inner periphery of the sheath. In such cases, it is not possible to achieve the necessary flow of blood being transferred. If the blood circulation is caused under a constant pressure by a blood-transfusion pump in the extracorporeal circulation circuit, the insufficient flow of blood resulting from the insufficient flow passage area leads to increased pressure loss, thereby involving the risk of homolysis. On the other hand, if the inner diameter of the sheath is more than 10 mm, the percutaneous insertion of the sheath will be difficult.

In carrying out the present invention, if the sheath of the introducing instrument has at least one side hole formed therein, it is possible, when a catheter is inserted into the sheath and indwelt, to assure a sufficient area of opening through which blood flows, thereby enabling the attainment of the necessary blood-transfusion amount.

In carrying out the present invention, if the base of the introducing instrument has a passage capable of communicating with a tube having a cock at one end thereof, this passage may be used to inject a medicine liquid or to collect blood during the heart treatment.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional view of the essential parts of an example of a catheter according to the present invention;

Fig. 2 is a sectional view of the essential parts of an example of a connecting instrument used in combination with the catheter;

Fig. 3 is a sectional view of an example of a blood vessel expander used in combination of the catheter;

Fig. 4 is a sectional view showing a state of use of the catheter;

Fig. 5 is a view schematically showing an indwelt state of the catheter;

Fig. 6 is a sectional view showing another state of use of the catheter;

Fig. 7 is a sectional view of an example of an introducing instrument of an extracorporeal circulation assembly according to the present invention;

Fig. 8 is a sectional view of an example of a connecting instrument of the assembly; and

Fig. 9 is a sectional view of an example of a blood vessel expander used in the assembly.

#### BEST MODE FOR CARRYING OUT THE INVENTION

## (First Embodiment)

A catheter assembly 10 basically comprises a catheter 20 and a connecting instrument 30, and additionally comprises a dilator 40.

The catheter 20 comprises, as shown in Fig. 1, a body 21 and a proximal end 22.

The body 21 of the catheter 20 is used in the state of being percutaneously inserted into the blood vessel. The catheter body 21 has an opening 21E at the distal end (hereinafter referred to as "the distal-end hole"), and a plurality of side holes 21H.

The proximal end 22 of the catheter 20 is joined to one end portion of the catheter body 21 to communicate therewith, and has an introduction passage 23. The introduction passage 23 has a hemostatic valve 25 which is disposed in an opening portion of the passage 23 and provided to prevent leakage of blood from the catheter body 21 to the outside.

The proximal end 22 also has a sub-passage 27 capable of communicating with a tube having a cock at one end thereof, so as to function as a port which may be used to inject a medicine liquid or collect blood.

The catheter 20 should preferably have an inner diameter of the body 21 which is within the range from 2 to 10 mm in order to facilitate the percutaneous insertion of the catheter body 21. If this inner diameter is less than 2 mm, there is a risk that, during emergency auxiliary circulation, the amount of drawn-out or sent-in blood may fall short of the necessary amount. If the inner diameter exceeds 10 mm, the percutaneous insertion of the catheter 20 will be difficult.

The catheter 20 has the following arrangement. When the opening area of the distal-end hole 21E of the catheter body 21 is expressed as  $S_1$ , and the total opening area of the side holes 21H is expressed as  $S_2$  ( $S_2 = N \times S_h$  if there are  $N$  side holes 21H which each have an area of  $S_h$ ), the relation of  $2 \times S_1 \geq S_2 \geq 0.5 \times S_1$  is satisfied. In other words, the total opening area  $S_2$  of the side holes 21H ranges from 1/2 to 2 times of the opening area  $S_1$  of the distal-end hole 21E. If  $S_2$  is smaller than  $1/2 \times S_1$ , when the catheter is on the blood-drawing side, the amount of blood drawn from the region where the side holes open, i.e., from the vena cava, will be insufficient. If  $S_2$  is greater than  $2 \times S_1$ , the amount of the blood drawn from the superior vena cava will be insufficient.

The position at which the side holes 21H are indwelt should preferably be as follows. If the catheter 20 is inserted into the femoral vein A, as shown in Fig. 5, the side holes 21H should be positional within the inferior vena cava C and in the region from the entrance of the right atrium B to

the bifurcation D of the inferior vena cava C (the symbol E designating the superior vena cava). This is because, in this region, blood flows in such a sufficient amount as to assure the drawing of the necessary amount of blood. Therefore, if this position of the side holes 21H relative to the patient's body is translated into their position relative to the catheter body 21 itself, the following can be said. The whole length  $L_2$  of the catheter body 21 must correspond to the sum of the first distance from the right atrium to the bifurcation of the inferior vena cava, the second distance from the bifurcation to the position where the catheter is percutaneously inserted into the femoral vein, and an additional length  $\alpha$  of the catheter outside the patient's body. In the case where the patient's body has a first distance of 30 to 40 cm and a second distance of 15 to 20 cm (as in the case of an American), the required whole length  $L_2$  of the catheter body 21 is 60 cm. In this case, in order to assure the necessary amount of drawn-out blood, the side holes 21H should preferably be positioned occupying a length from the distal end of the catheter body 21 which is 40 cm at most. Therefore, the whole length  $L_2$  of the catheter body 21 should satisfy the following relation with the distance  $L_1$  from the distal end of the catheter body 21 to the side hole closest to the proximal end 22:  $2/3 \times L_2 \geq L_1$ . In the case where the patient's body is relatively small (as in the case of Japanese; the patient requiring extracorporeal circulation by the use of the catheter according to the present invention often has a relatively small body), and where the first distance is about 2/3 of the corresponding hemostatic value in above-described case, i.e., about 20 cm, the whole length  $L_2$  and the distance  $L_1$  should satisfy the relation of  $L_1 \geq 1/3 \times L_2$ . Thus, it is preferable that the whole length  $L_2$  and the distance  $L_1$  should satisfy the relation expressed as follows:

$$2/3 \times L_2 \geq L_1 \geq 1/3 \times L_2$$

If the catheter 20 satisfies this relationship it is possible to attain the necessary amount of blood drawn whether the patient's body is large or small.

The catheter body 21 is made of a material such as a fluoroplastic, polyethylene, polypropylene, or a polyester-based elastomer. The proximal end 22 is made of a material such as polyethylene, polypropylene, polyamide, polycarbonate, or polystyrene.

As shown in Fig. 2, the connecting instrument 30 has a tubular portion 31 which can be connected with the introduction passage 23 in the proximal end 22 of the catheter 20, and be inserted in a liquid tight manner through the hemostatic valve in the introduction passage 23. The other end of the tubular portion 31 is connected with the blood drawing-out or pumping-in line of the extracorporeal circulation circuit. The connecting in-

strument 30 also has a threaded connecting cap 32 on the outer periphery of the tubular portion 31. When a female screw 32A of the connecting cap 32 is threaded onto a male screw 23A provided around the introduction passage 23 of the proximal end 22, the connecting instrument 30 is fixed to the catheter 20.

The catheter assembly 10 is such that, when the connecting instrument 30 is connected with the introduction passage 23 of the catheter proximal end 22, as shown in Fig. 4, the distal end of the tubular portion 31 of the connecting instrument 30 is disposed adjacent to the inner surface of the catheter body 21. In this embodiment, that distal end abuts on the inner surface of the catheter body 21.

The inner surface of the tubular portion 31 of the connecting instrument 30 is tapered, more specifically, converged with its diameter decreasing toward the distal end of the portion 31.

The tapering angle  $\theta$  (in Fig. 4) at which the inner surface of the tubular portion 31 is tapered should preferably be 5 to 15 degrees.

The tubular portion 31 of the connecting instrument 30 is made of a material such as polycarbonate, a vinyl chloride resin, or polypropylene, while the cap 32 is made of a material such as polyamide, polycarbonate, or a vinyl chloride resin.

The dilator 40 is capable of being inserted into and through the introduction passage 23 of the proximal end 22 of the catheter 20 as well as the body 21 of the catheter 20 so as to lead the catheter body 21 into the blood vessel. As shown in Fig. 3, the dilator 40 comprises a body 41 and a proximal end with a threaded connecting cap 42 provided around the proximal end. When a female screw 42A of the connecting cap 42 is threaded onto the male screw 23A provided around the introduction passage 23 in the catheter base, 22 the dilator is integrated with the catheter 20. The body 41 of the dilator 40 is capable of being inserted in a liquid tight manner through the hemostatic valve 25 in the introduction passage 23 of the catheter 20. The dilator 40 also has a hemostatic valve 43 provided at the outer end of the cap 42. The dilator 40 allows the insertion therethrough of a mini guide wire 44 when the wire 44 is passed through the hemostatic valve 43 in a liquid tight manner.

The dilator body 41 is made of a material such as polyethylene, polypropylene, or a polyester-based elastomer, while the connecting cap 42 is made of a material such as polyamide, polycarbonate, or a vinyl chloride resin.

The catheter 20 of the above-described catheter assembly 10 is inserted into and indwelt in the blood vessel in the following manner:

(1) An indwelling needle having an outer needle

member and an inner needle member fit therein is percutaneously inserted into the blood vessel.

(2) The inner needle member is removed. The mini guide wire 44 is passed through the outer needle member to be indwelt in the blood vessel. After the indwelling, the outer needle member is removed.

(3) The catheter 20 and the dilator 40 integrated therewith are inserted into the blood vessel while they are guided by the mini guide wire 44. After the insertion, the mini guide wire 44 and the dilator 40 are removed, thereby indwelling the catheter 20 in the blood vessel.

The catheter 20 indwelt in the blood vessel is used in the following manner:

(1) When auxiliary blood circulation is to be performed during PTCA or IABP heart treatment or during the treatment of acute myocardial infarction or heart failure, the connecting instrument 30 is inserted into the introduction passage 23 of the catheter 20. By virtue of the hemostatic valve 25 of the introduction passage 23, the connecting instrument 30 is inserted into the passage 23 in a liquid tight manner and without the risk of blood leakage.

(2) The connecting instrument 30 of the catheter assembly 10 on the blood-drawing side is connected with the blood-drawing line of the extracorporeal circulation circuit so that blood is drawn from the patient's body through the catheter body 21 and the tubular portion 31 of the connecting instrument 30.

(3) The connecting instrument 30 of the catheter assembly 10 on the blood pumping-in side is connected with the blood pumping-in line of the extracorporeal circulation circuit so that the extracorporeally circulated blood is pumped into the blood vessel through the tubular portion 31 of the connecting instrument 30 and the catheter body 21.

The catheter 20 according to the present invention can be percutaneously inserted into the femoral vein in such a manner that the distal-end hole 21E of the catheter body 21 is positioned in the vicinity of the right atrium, and can be connected with the blood-drawing line of the extracorporeal circulation circuit so as to draw blood from the right atrium and the venae cavae. At this time, the position of the side holes 21H of the catheter body 21 is such that the holes 21H are distributed from the vicinity of the bifurcation of the inferior vena cava to the vicinity of the right atrium.

The catheter 20 provides the following advantages (1) to (3):

(1) The catheter 20 allows blood to be drawn out or pumped in through not only the distal-end hole 21E of the catheter body 21 but also the side holes 21H thereof. Therefore, the catheter

20 according to the present invention is capable of reducing the resistance to the flow of blood from the blood vessel to the catheter body 21 or vice versa, thereby reducing the pressure loss. Thus the catheter 20, of which the diameter is small enough to facilitate the percutaneous insertion of the catheter 20, is capable of reducing the pressure loss, hence, of assuring sufficient amount of drawn-out or pumped-in blood.

(2) When the catheter 20 is used on the side of the blood-drawing line, by virtue of the provision of the side holes 21H in the catheter body 21, the negative pressure applied through the blood-drawing line to the body 21 is distributed among the distal-end hole 21E and the side holes 21H of the catheter body 21, thereby reducing the risk that the negative pressure may cause the blood vessel wall to be sucked by the body 21, to close the inlets (the distal-end hole 21E and the side holes 21H) through which blood flows in.

(3) It is possible to assure that the amount of blood drawn out or pumped in through the distal-end hole 21E is at least at a certain proportion to the total amount of drawn-out blood. Therefore, a certain amount of blood can be positively drawn out or pumped in at the target portion within the blood vessel where the leading end of the catheter body is indwelt, relative to the amount of blood drawn out or pumped in through the side holes.

This advantage will be understood clearly by considering the following case. When the body 21 of the catheter 20 is percutaneously inserted into, for instance, the femoral vein with the distal-end hole 21E being positioned in the right atrium, as described above, so as to draw blood, if all of the amount of blood to be extracorporeally circulated is drawn through the side holes 21H, this makes it impossible for blood from the superior vena cava to be circulated in the extracorporeal circuit, thereby resulting in a very dangerous state. In contrast, the catheter 20 according to the present invention in such that, as described in (3), it does not cause all of the circulation amount to be drawn through the side holes 21H, but causes a large amount of blood to be drawn through the distal-end hole 21E. Thus, the catheter 20 enables blood which is circulating from the superior vena cava to the right atrium to be drawn through the distal-end hole 21E and extracorporeally circulated.

Experiments were conducted on a specific sample of the catheter 20, in which the length of the body 21 was 20 cm, the inner diameter was 5.2 mm, the number of side holes 21H was six, the diameter of the side holes 21H was 2.1 mm, and the side holes 21H were formed at intervals of 5 cm within a region extending through 30 cm from

the distal-end of the body 21. The opening area S1 of the distal-end hole 21E was 21.23 mm<sup>2</sup>, and the total opening area of the side holes 21H was 20.76 mm<sup>2</sup>, thereby satisfying the relation of S1 > S2. As a result, the catheter 20, which had a diameter small enough to facilitate percutaneous insertion at the time of auxiliary blood circulation, was found to be capable of assuring a sufficient amount of drawn-out or pumped-in blood.

According to the above-described embodiment, since the catheter 20 has the sub-passage 27 at the base 22, it is possible to use the passage 27 to perform the injection of a medicine liquid or the collection of blood simultaneously with heart treatment or the like.

In carrying out the present invention, the introduction passage of the base of the catheter may allow the insertion of an insertion body other than the connecting instrument connected with the blood-drawing line or the blood pumping-in line of the extracorporeal circulation circuit. For instance, a catheter for heart treatment (e.g., a unit having a guide catheter and a balloon catheter guided thereby), or a connecting instrument connected with a medicine liquid supply line may be inserted into the introduction passage.

#### (Second Embodiment)

A catheter assembly 50, shown in Fig 6, is a modification of the above-described catheter assembly 10. Similarly to the catheter assembly 10, the catheter assembly 50 basically comprises a catheter 20 and a connecting instrument 30, and additionally comprises a dilator 40.

The substantial difference of the catheter assembly 50 from the catheter assembly 10 is that when the connecting instrument 30 is connected to the introduction passage 23 of the catheter 20, the distal-end of the tubular portion 31 of the connecting instrument 30 does not abut on the inner surface of the body 21 of the catheter 20, but is disposed close to the inner surface with a certain gap.

Therefore, with the catheter assembly 50, when the sub-passage 27 in the proximal end 22 of the catheter 20 is connected through a side tube 51 and a three-way cock 52 to a pressure transducer (not shown) so as to measure the blood pressure, the blood pressure introduced by the catheter body 21 can be applied to the sub-passage 27 through the gap between the inner surface of the body 21 and the distal-end of the tubular portion 31, thus without any substantial resistance. This enables highly precise pressure measurement.

## (Third Embodiment)

An assembly for extracorporeal circulation basically comprises an introducing instrument 120 and a connecting instrument 130, and additionally comprises a dilator 140.

The introducing instrument 120 comprises, as shown in Fig. 7, a sheath 121 and a proximal part 122.

The sheath 121 is used in the state of being percutaneously inserted into the blood vessel. The sheath 121 includes a plurality of side holes 121H.

The proximal part 122 of the introducing instrument 120 is jointed to one end portion of the sheath 121 to communicate therewith, and has a first introduction passage 123 as well as a second introduction passage 124. The introduction passages 123 and 124 have hemostatic valves 125 and 126, respectively, which are disposed in opening portion of the passages 123 and 124, and provided to prevent leakage of blood from the sheath 121 to the outside.

The proximal part 122 also has a sub-passage 127 capable of communicating with a tube having a cock at one end thereto, so as to function as a port which may be used to inject a medicine liquid or collect blood.

The sheath 121 is made of a material such as a fluoroplastic, polyethylene, or a polyester-based elastomer. The proximal part 122 is made of a material such as polyethylene, polypropylene, polyamide, polycarbonate, or polystyrene.

As shown in Fig. 8, the connecting instrument 130 has a tubular portion 131 which can communicate with the first introduction passage 123 in the proximal part 122 of the introducing instrument 120, and be inserted in a liquid tight manner through the hemostatic valve 125 in the introduction passage 123. The other end of the tubular portion 131 is connected with the blood-transfusion line of the extracorporeal circulation circuit. The connecting instrument 130 also has a threaded connecting cap 132 on the outer periphery of the tubular portion 131. When a female screw 132A of the connecting cap 132 is threaded onto a male screw 123A provided around the first introduction passage 123 of the proximal part 122, the connecting instrument 130 is fixed to the introducing instrument 120.

The tubular portion 131 of the connecting instrument 130 is made of a material such as polycarbonate, a vinyl chloride resin, or polypropylene, while the cap 132 is made of a material such as polyamide, polycarbonate, or a vinyl chloride resin.

The dilator 140 is capable of being inserted into and through the first introduction passage 123 of the proximal part 122 of the introducing instrument 120 as well as the sheath 121 of the instru-

ment 120 so as to lead the sheath 121 into the blood vessel. As shown in Fig. 9, the dilator 140 comprises a body 141 and a proximal part with a threaded connecting cap 142 provided around the proximal part. When a female screw 142A of the connecting cap 142 is threaded onto the male screw 123A provided around the first introduction passage 123 in the proximal part 122, the dilator 140 is integrated with the introducing instrument 120. The body 141 of the dilator 140 is capable of being inserted in a liquid tight manner through the hemostatic valve 125 in the introduction passage 123 of the proximal part 122. The dilator 140 also has a hemostatic valve 143 provided at the outer end of the cap 142. The dilator 140 allows the insertion therethrough of a mini guide wire 144 when the wire 144 is passed through the hemostatic valve 143 in a liquid tight manner.

The dilator 141 is made of a material such as polyethylene, polypropylene, or a polyester-based elastomer, while the connecting cap 142 is made of a material such as polyamide, polycarbonate, or a vinyl chloride resin.

The introducing instrument 120 of the above-described extracorporeal circulation assembly is inserted into and indwelt in the blood vessel in the following manner:

(1) An indwelling needle having an outer needle member and an inner needle member fit therein is percutaneously inserted into the blood vessel.

(2) The inner needle member is removed. The mini guide wire 144 is passed through the outer needle member to be indwelt in the blood vessel. After the indwelling, the outer needle member is removed.

(3) The introducing instrument 120 and the dilator 140 integrated therewith are inserted into the blood vessel while they are guided by the mini guide wire 144. After the insertion, the mini guide wire 144 and the dilator 140 are removed, thereby indwelling the introducing instrument 120 in the blood vessel.

The introducing instrument 120 indwelt in the blood vessel is used in the following manner:

(a) First an insertion body such as a PCTA catheter (a unit having a guide catheter and a balloon catheter guided thereto) is inserted into the second introduction passage 124 in the proximal part 122 of the introducing instrument 120 while this catheter is guided by a guide wire already passed through the second introduction passage 124. By virtue of the hemostatic valve 126 of the second introduction passage 124, the catheter is inserted into the introduction passage 124 in a liquid tight manner and without the risk of blood leakage. The inserted catheter is introduced, through the sheath 121, to the target portion in the blood vessel (the lesion in the coronary artery).

balloon catheter may be introduced into the introduction passage 124 of the introducing instrument 120 while this catheter wire already passed through the introduction passage 124. Also the valve 126 of the second introduction passage 124 enables the liquid insertion of the catheter through the introduction passage 124. The inserted catheter goes through the sheath 121, to the blood vessel (the proximal

or IABP heart treatment goes into a shocked state necessary to strengthen the IABP, the connecting instrument into the first introduction passage of the introducing instrument 120. By the valve 125 of the first introduction passage 123 in the connecting instrument 130 is without the risk of blood transfusion line of an extracorporeal circulation circuit, so that, simultaneously with the IABP operation, the blood and oxygenated blood is inserted into the blood vessel through the connecting instrument 130.

In a critical condition, the catheter may be inserted into the introduction passage 123 of the introducing instrument 120 at the start of the PTCA or extracorporeal circulation if necessary. In this way, treatment can be performed safely.

In this embodiment, the diameter of the PTCA catheter, inserted into the introducing instrument 120 is 9F. Therefore, in order to insert the catheter into the blood vessel from the blood vessel through the connecting sheath 121 into the blood vessel, the sheath 121 should be, more preferably 5 to 7 mm, before in the summary.

In this embodiment, since the introducing instrument 120 has a side hole, when a catheter is inserted into the sheath 121 and indwelt, the side hole opening through which is able to attain the amount.

In this embodiment, since

the proximal part 122 of the introducing instrument 120 has the sub-passage 127, it is possible to use the passage 127 to perform the injection of a medicine liquid or the collection of blood simultaneously with heart treatment or the like.

In carrying out the present invention, the proximal part of the introducing instrument may have three or more introduction passages.

In carrying out the present invention, a plurality of connecting instruments may be individually connected to two or more introduction passages of the proximal part of the introducing instrument.

In carrying out the present invention, the introduction passages of the proximal part of the introducing instrument may allow the insertion of insertion bodies other than the catheter and the connecting instrument connected with the blood transfusion line of the extracorporeal circulation circuit. For instance, a connecting instrument connected with a medicine liquid supply line may be inserted into the introduction passage.

#### (Effects of the Invention)

As has been described above, according to the present invention, there is provided a catheter that has a diameter small enough to facilitate percutaneous insertion at the time of auxiliary blood circulation but is capable of assuring a sufficient amount of drawn-out or pumped-in blood.

According to the present invention, there is also provided an assembly for extracorporeal circulation that enables extracorporeal circulation to be effected simultaneously with the execution of heart treatment.

#### Claims

1. A catheter comprising:  
a hollow body introducible into the blood vessel and opened at a distal end thereof; and  
a proximal end communicating with the hollow inside of said body and having an introduction passage with a hemostatic valve disposed therein,  
said body having side hole means formed therein.
2. A catheter according to claim 1, wherein said body has a plurality of side holes.
3. A catheter according to claim 1 or 2, wherein when the area of the opening at the distal end of said body is expressed as S1 and the total opening area of said side hole means is expressed as S2, the relation of  $2 \times S1 \geq S2 \geq 0.5 \times S1$  is satisfied.
4. A catheter according to any of claims 1 to 3, wherein when the distance from the distal end of said body to the side hole closest to said proximal end is expressed as L1 and the whole length of

said body is expressed as L2, the relation of  $2/3 \times L2 \geq L1 \geq 1/3 \times L2$  is satisfied.

5. An assembly for extracorporeal circulation comprising:

an introducing instrument; and

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a connecting instrument,

said introducing instrument including a sheath introducible into the blood vessel, and a proximal part communicating with said sheath and having a plurality of introduction passages with hemostatic valves disposed therein,

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said connecting instrument including a tubular portion capable of being connected with at least one of said introduction passages of said proximal part of said introducing instrument and capable of being inserted in a liquid-tight manner through the hemostatic valve disposed in the connected introduction passage.

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6. An assembly according to claim 5, wherein said sheath of said introducing instrument has an inner diameter of 3 to 10 mm.

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7. An assembly according to claim 5 or 6, wherein said sheath of said introducing instrument has side hole means formed therein.

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8. An assembly according to claim 5, wherein said proximal part of said introducing instrument has a passage capable of communicating with a tube having a cock at one end thereof.

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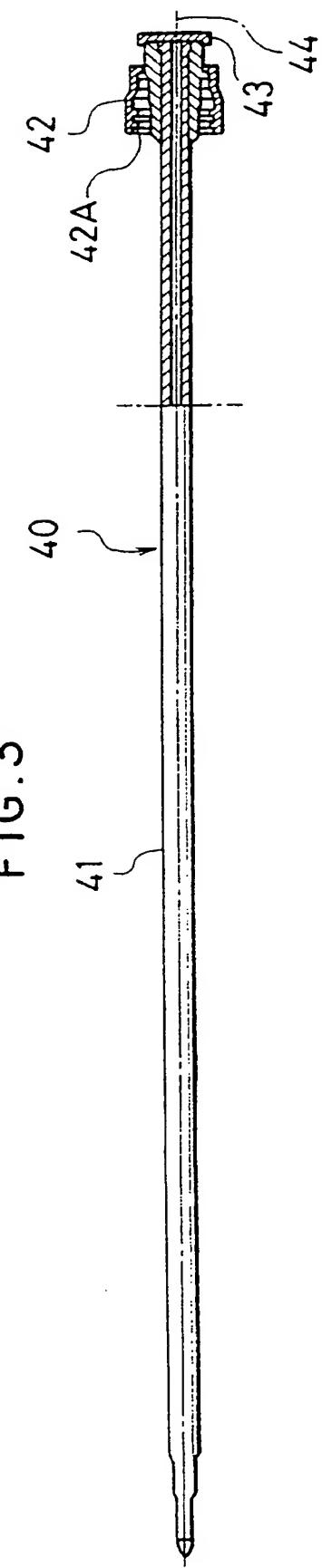
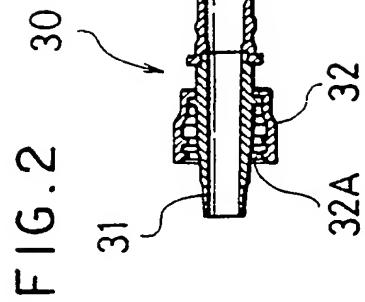
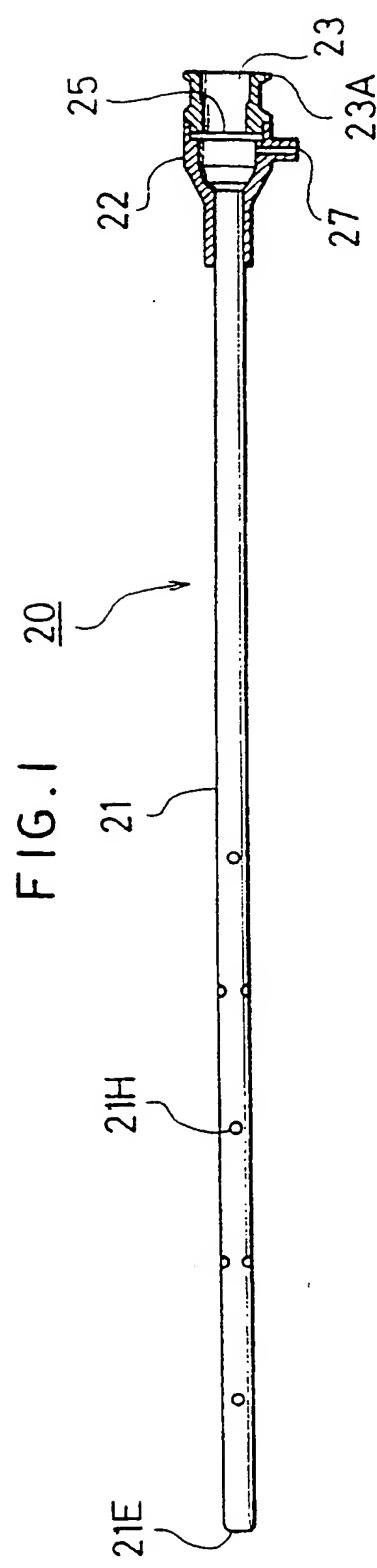


FIG. 4

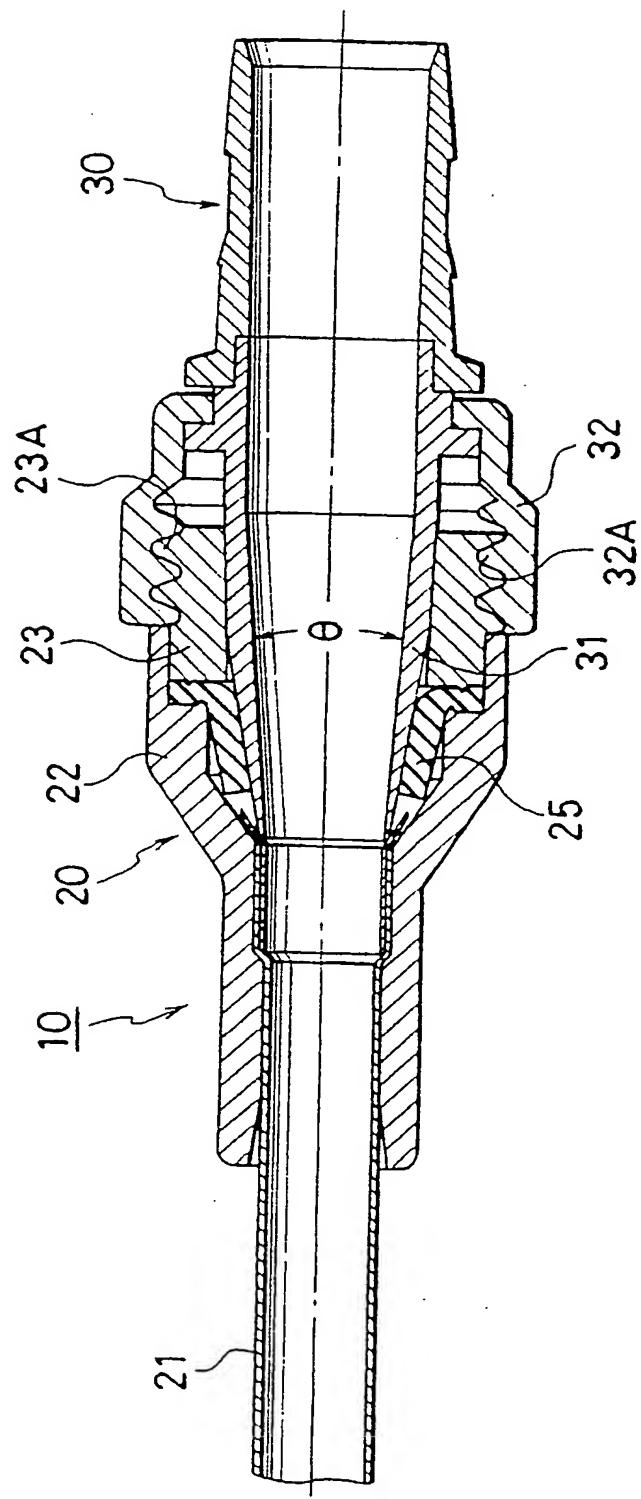


FIG. 5

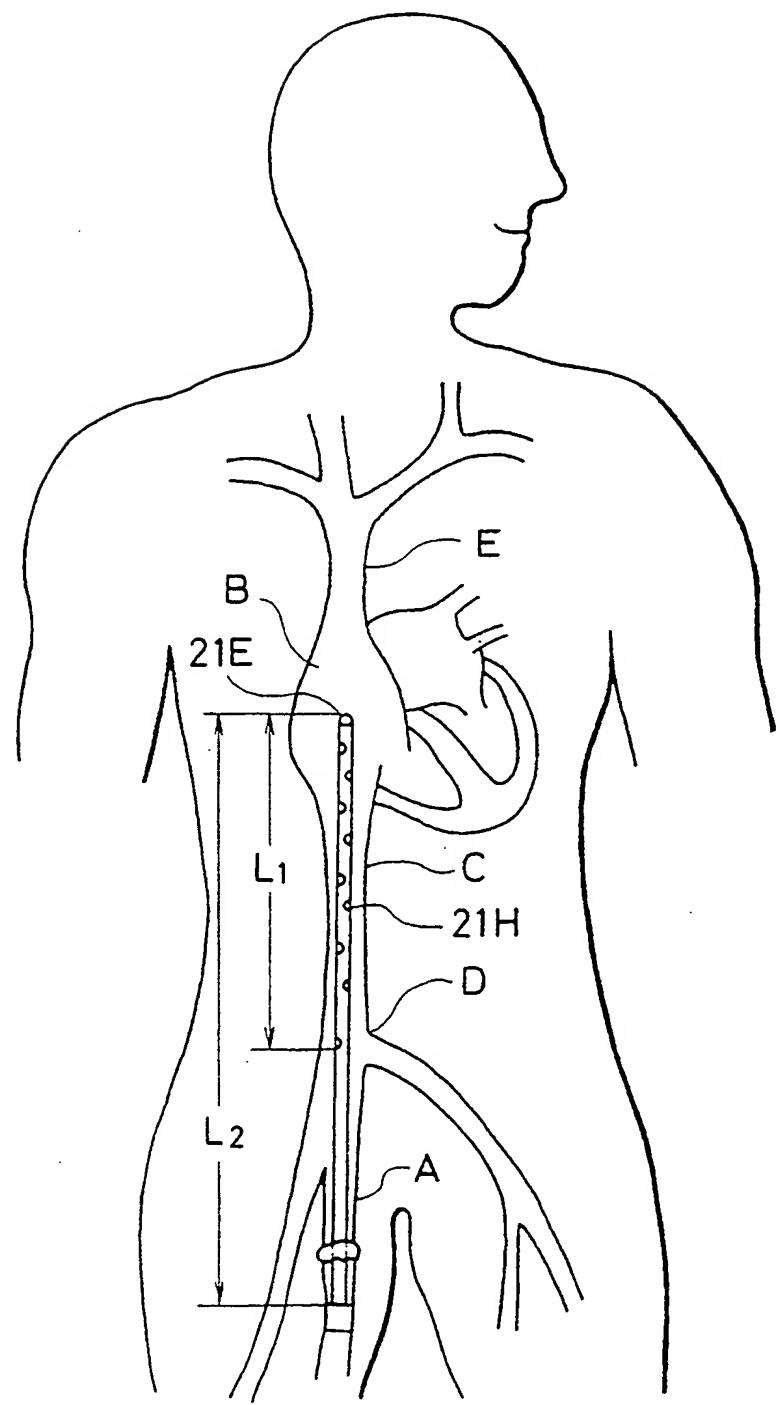
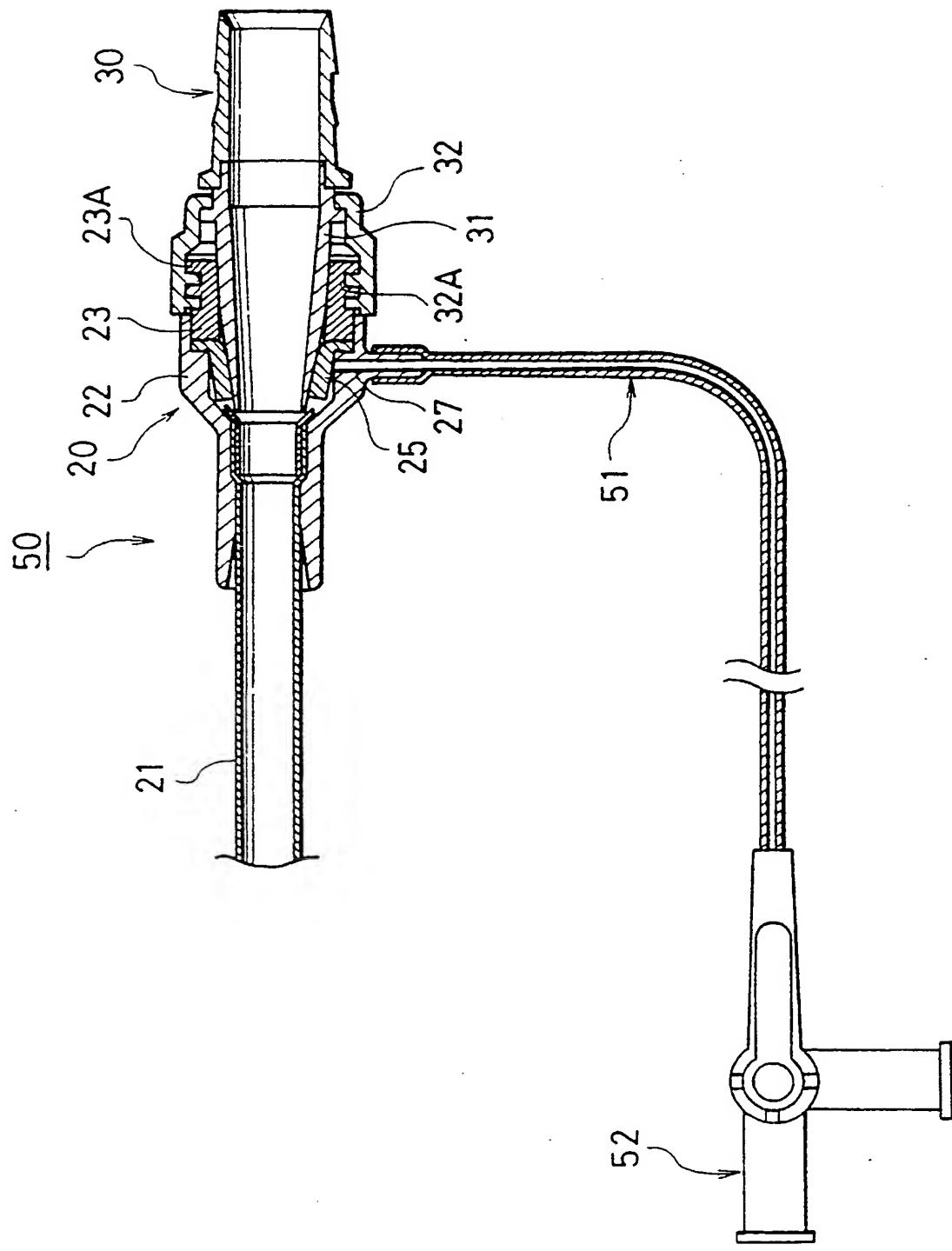
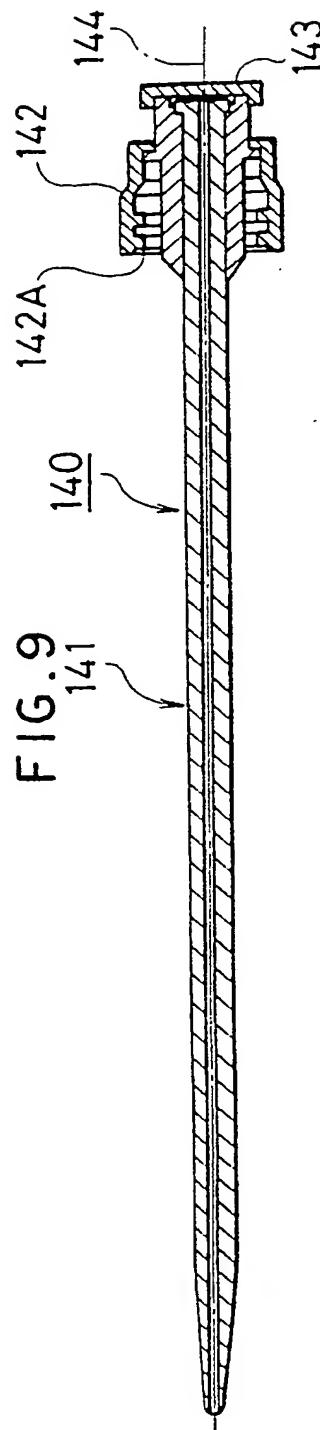
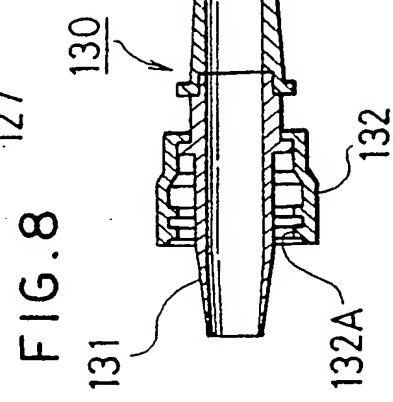
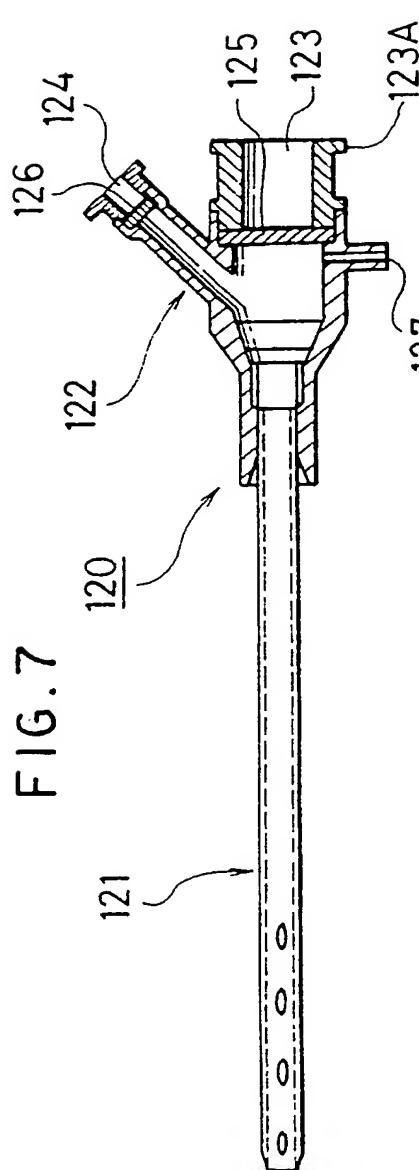


FIG. 6







DOCUMENTS CONSIDERED TO BE RELEVANT			EP 90114762.9
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 5)
X	<u>US - A - 3 547 119</u> (J.P. HALL) * Fig. 3; column 1, line 53 - - column 2, line 7 *	1, 2	<b>A 61 M 25/00</b>
Y	--	5, 7	
Y	<u>US - A - 3 565 078</u> (V.L. VAILLIANCOURT) * Fig. 1,5; column 2, lines 5-22 *	5, 7	
A	--		
A	<u>US - A - 4 173 981</u> (J.D. MORTENSEN) * Abstract; fig. 3 *	1-3, 6, 7	
A	--		
A	<u>FR - A1 - 2 565 491</u> (J.R. MONTIES) * Fig. 1; page 3, line 18 - - page 4, line 24 *	5, 8	
Y	--		
Y	<u>EP - A2 - 0 212 159</u> (STÖCKERT INSTR.) * Fig. 1-3; column 4, line 44 - page 5, line 29 *	1, 2	TECHNICAL FIELDS SEARCHED (Int. Cl. 5)
Y	--		<b>A 61 M</b>
Y	<u>GB - A - 2 065 479</u> (TECHN. SUPPLY) * Fig. 1,2; page 1, line 98 - page 2, line 44; abstract *	1, 2	
A	--		
A	<u>THE ANNALS OF THORACIC SURGERY, vol. 336, no. 2, August 1983</u> PHILLIPS et al. "Percutaneous Initiation of Cardiopulmonary Bypass" pages 223-225 * Totality *	1, 2, 4 7	
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<p>The present search report has been drawn up for all claims</p>			
Place of search	Date of completion of the search	Examiner	
VIENNA	12-11-1990	LUDWIG	
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			